TIP GEOMETR ARTIFACTS ON THE SHAPE OF COPPER MICROSTRUCTURES FABRICTED BY LOCALIZED ELECTROCHEMICAL DEPOSITION

R.A. Said
United Arab Emirates University
Electrical Engineering Department, P.O. Box: 17555,
Al-Ain, United Arab Emirates

The effect of the electrode tip geometry on copper micro-structures, fabricated by localized electrochemical deposition, is investigated experimentally and explained through the numerical calculation of electric field distribution.

EFFECT OF SYMMETRY IN TIP GEOMETRY

The shape of copper microstructures, fabricated by localized electrochemical deposition (1), is found to be influenced by the used microelectrode tip geometry. For example, the photographs at the top of Fig. 1 show the end view of microelectrodes prepared by sealing the end of a glass tube around a 25µm Pt wire via heating and vacuum suction. The end result is a glass insulated Pt wire, located at a position determined during the glass solidification. The location of the electrode wire can have a drastic effect on the deposit shape, as evident in the SEM images in Fig. 1. The base of a column structure in Fig. 1(b), which is deposited by an electrode wit the Pt wire off-center of the electrode end, has an unsymmetrical profile and a wider and thicker surrounding deposit. This is attributed to the intensified electric field at the glass-air boundary, close to the electrode wire in the off-centered wire electrode geometry case, as confirmed by the electric field distribution calculations in Fig. 2. The calculations were carried by solving the electric field static integral equation using a boundary element approach (2).

EFFECT OF INSULATING MATERIAL

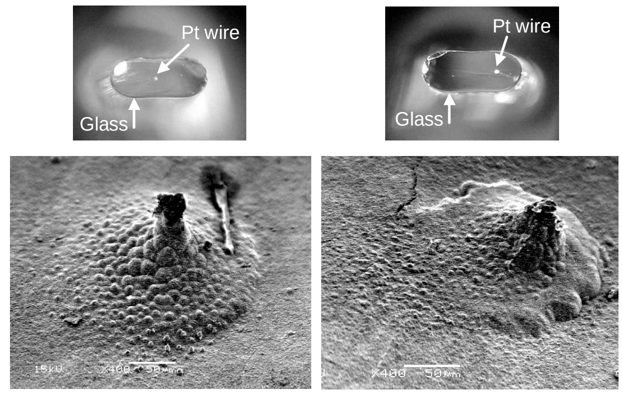
Aside from the symmetry differences in the deposit shapes in Fig. 1, both deposits have base dimensions much larger than 25µm, anticipated from the electrode wire diameter. This is due to the permittivity of the insulating glass, which acts as a guide for the electric field lines emanating from the electrode wire. This further spreads the field lines around the wire end and decreases deposit localization, as apparent from the contrast in the electric field distribution in Fig. 2. The strength of the electric field around the electrode wire creates an effective diameter of the wire that is much larger than its original dimension. To reduce this effect, the insulating glass around the electrode tip is removed, giving a tapered probe end as in Fig. 3(b). The suggested reasoning above is verified by the SEM images in Fig. 4, which demonstrate a confined deposition using tapered electrode tips.

ACKNOWLEDGMENT

This research was financially supported by the Scientific Research Council at the United Arab Emirates University.

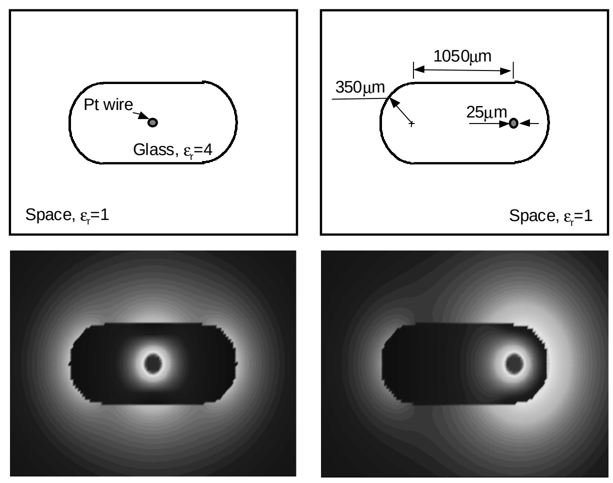
REFERENCES

1. J.D. Madden and I.W. Hunter, J. Micro-electromechanical Systems, **5**, 24(1996).
2. C. A. Brebbia, The Boundary Element Method for Engineers, Pentech Press, England 1984.



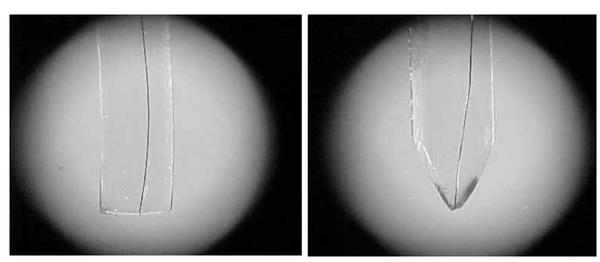
(a) (b)

Fig. 1: Top: photographs of the end view of glass insulated Pt wire electrodes with the wire tip at (a) the center and (b) off set position. Bottom: SEM images of column base deposited by the corresponding tip. Pt wire diameter is 25 µm.



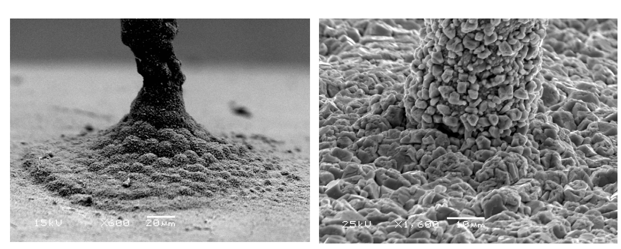
(a) (b)

Fig. 2: Calculated electric field distribution at the electrode end for (a) centered and (b) off centered wire configurations shown in the drawings at the top.



(a) (b)

Fig. 3: Photograph of glass insulated Pt wire electrode with: (a) flat-end , and (b) tapered-end glass insulation.



(a) (b)

Fig. 4: SEM images of columns bases deposited using: (a) the electrode in Fig. 3(a), and (b) the electrode in Fig. 3(b).